Variation in Epinephrine and Cortisol Excretion Rates Associated With Behavior in an Australian Aboriginal Community

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ABSTRACT Urinary epinephrine and cortisol hormone output in a remote Australian Aboriginal community was on average about twice as high in those individuals measured on a Thursday or Friday as those measured at the beginning of the next week (Monday or Tuesday). Diastolic blood pressure was about 6 mm Hg higher in the Thursday–Friday group, but the difference in mean systolic blood pressure between the day groups does not reach statistical significance. These physiological differences are associated with a marked dichotomy in behavior in the two time periods: on the first 2 days, virtually all adults were involved in intense gambling activity for large stakes, but this was not a feature of the latter period. This behavior pattern occurs on a regular weekly basis. If substantiated by longitudinal studies, this phenomenon may provide an additional link between human behavior and a poor health profile mediated via the physiological consequences of high stress hormone output. Am J Phys Anthropol 106:249–253, 1998.

Epinephrine and cortisol are central elements in the maintenance of homeostasis and the stress response, but chronically high levels have been implicated in the etiology of some of the so-called lifestyle diseases, including hypertension, coronary heart disease, and non–insulin dependent diabetes mellitus (e.g., Steptoe, 1981; Kenyon and Fraser, 1992; Björntorp, 1996). Experimental studies have revealed a plethora of noxious stimuli that elevate stress hormone excretion rates. More carefully controlled experiments have revealed that many of these responses are due to the cognitive appraisal of the stimulus, and it has been suggested that everyday living experiences are a major determinant of endocrine hormone output variation (Mason, 1971; Mason et al., 1976). Anthropological studies that have revealed an association between lifestyle and hormone excretion include comparisons of migrant groups (e.g., Brown 1982; Pearson et al., 1990) and the level of self-reported stress and busyness (e.g., Pollard et al., 1992).

A recent study revealed exceptionally high urinary cortisol excretion rates in three Australian Aboriginal communities in the Kimberley region that are undergoing rapid sociocultural change. Epinephrine excretion was also high in the same groups by world standards (Schmitt et al., 1995). The factors responsible for these high populational levels and for the variation within communities are difficult to determine. In this paper we describe in more detail urinary stress hormone excretion rates found in one of those communities and note its association with a marked change in the behavior of most

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members of the community during the course of the sampling period. In this community, the behavioral change occurs on a regular weekly basis.

SUBJECTS AND METHODS

A urine specimen was collected from 62 adult volunteers aged 19–67 years as part of an investigation of stress hormone output in Kimberley Aboriginal people (Schmitt et al., 1995). The subjects live in a community of about 350 people in a tropical environment and about 600 km from the nearest town. Virtually all individuals in this community share some genetic relationship. Subjects came to the local health clinic, a central site in the community, at about 3 PM, when they voided their bladder, and weight, stature, and blood pressure (assessed with an electronic digital sphygmomanometer) were recorded. They then resumed their usual activities until around 5 PM, when they returned and voided their bladder, and the urine was collected. Epinephrine and cortisol were assayed by high pressure liquid chromatography (Jenner et al., 1981; Jenner and Richards, 1985).

For the analyses described here, each sample was allocated to one of two day groups according to the day of urine collection, either Thursday–Friday or Monday–Tuesday. Each individual contributed one sample only. Many people received wages or social benefits on Thursday around midday, when work ceased and almost all members of the community became involved in card gambling for large stakes over the next 2 days. While gambling continued during the Monday and Tuesday collections, it involved far fewer individuals, and the stakes had become trivial.

Because the data design is unbalanced, multiple regression was used to assess the relationship between hormone output (as response variables) and day group, sex, age, urine flow rate, stature, and weight (as explanatory variables), with day group and sex coded as dummy variables. Both forward and backward selection methods were used, the latter beginning with all the three-way interaction terms involving sex and day group and each of the metric features. Except where noted, these two selection methods produced the same results. These multiple regression analyses are equivalent to extended forms of analysis of covariance for unbalanced data, with the added advantage that the assumptions of parallel slopes were assessed through the testing of interactions between discrete and continuous variables. Similar analyses of diastolic and systolic blood pressure as response variables were also undertaken. Hormone output, weight, and urine flow rate were log10 transformed before all analyses, and reported means are back-transformed values. Genstat (Genstat 5 Committee, 1993) was used for all statistical analyses.

RESULTS

The samples of the two day groups, Thursday–Friday and Monday–Tuesday, do not differ in sex ratio ($\chi^2 = 0.26$, $P = 0.61$) or the means of age, stature, or weight (Table 1). Urine flow rate is significantly higher in the Monday–Tuesday group, and cortisol and epinephrine excretion rates are significantly higher in the Thursday–Friday group. Both systolic and diastolic blood pressure are also higher in the Thursday–Friday group, but these differences do not quite reach statistical significance.

For epinephrine, multiple regressions revealed two statistically significant effects: a positive association with urine flow rate ($P = 0.008$) and a higher mean in the Thursday–Friday group ($P = 0.004$). The sexes were not significantly different in epinephrine excretion rates in this sample ($P = 0.318$), although the male mean was significantly greater than the female mean in the total regional sample (Schmitt et al., 1995). Correcting epinephrine output for urine flow rate revealed a pattern between the two day groups (Fig. 1) that was similar to the uncorrected values (Table 1).

Forward selection multiple regression with cortisol as the response variable revealed the Thursday–Friday group has a higher mean ($P = 0.027$), and this is the only significant effect. Backward elimination indicated two significant interactions: between age and sex and between stature and day group. The interactions arise because the

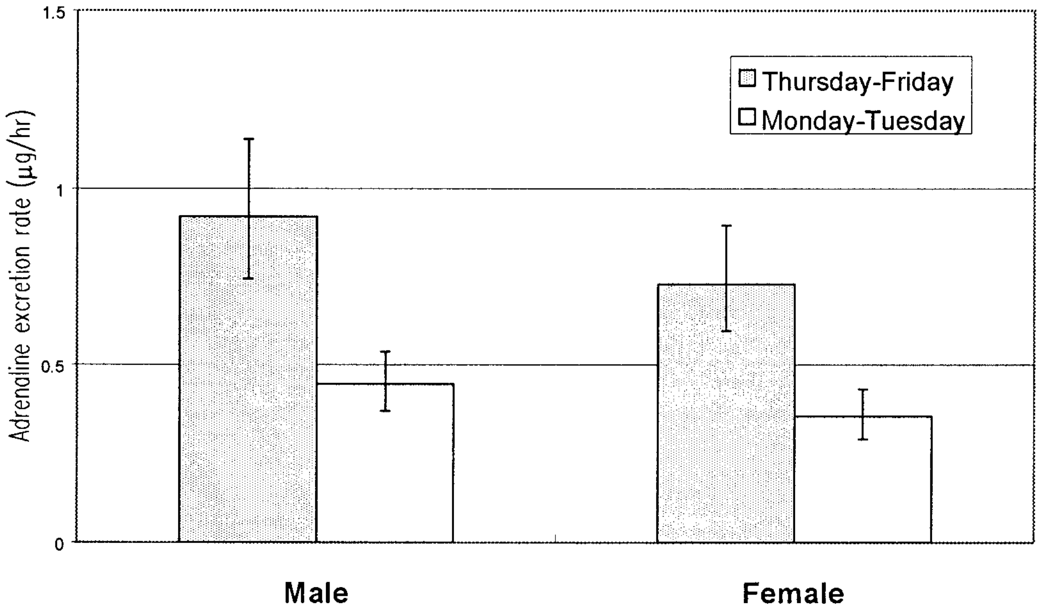

Fig. 1. Regression-corrected mean epinephrine (±1 standard error).

TABLE 1. Samples sizes (N), mean values for day groups, and probability values (P) for tests of significance of the equality of the two day groups

	Thursday–Friday	Monday–Tuesday	*P*
N males	13	18	
N females	15	16	
Age (years)	37.3	32.4	0.11
Stature (mm)	1694	1715	0.31
Weight (kg)	76.4	72.7	0.38
Urine flow rate (ml/h)	47.8	76.8	0.033
Epinephrine output (µg/h)	0.737	0.433	0.032
Cortisol output (µg/hr)	2.57	1.26	0.027
Diastolic blood pressure (mm Hg)	80.2	73.9	0.056
Systolic blood pressure (mm Hg)	129.8	119.5	0.054

regression of cortisol on age is different for males and females, and the regression on stature is different for the two day groups. These interaction effects are possibly a consequence of overfitting the regression model. Nonetheless, using the regression estimates to adjust statistically for these effects to the mean of age and stature (Fig. 2) reveals day group differences that are similar to the uncorrected data (Table 1). Adding urine flow rate to any of the models tested did not appreciably alter the results.

Multiple regression of diastolic blood pressure reveals significant associations with weight ($P < 0.001$), sex ($P = 0.006$), and day group ($P = 0.043$). Diastolic blood pressure is about 6 mm Hg higher in the Thursday–Friday group than the Monday–Tuesday group (Table 2). Systolic blood pressure is significantly associated with age ($P < 0.001$) and sex ($P = 0.001$), but the two day groups are not different ($P = 0.13$).

DISCUSSION

The community that forms the subject of this study experiences a regular weekly behavioral cycle which is directly related to the receipt of income. Most individuals receive their major cash income through fortnightly employment payments or government social payments, and these two forms are paid out on alternating weeks. At the time of this study, the payments occurred on the first day of urine collection, a Thursday around midday, and it immediately led to intense card gambling activity, involving substantial portions of the payment. Virtually all the adults in the community were involved either as players or spectators with a strong vested interest in the outcome. This intense gambling continued on the Friday but declined rapidly over the weekend, and by the Monday only a small proportion of the

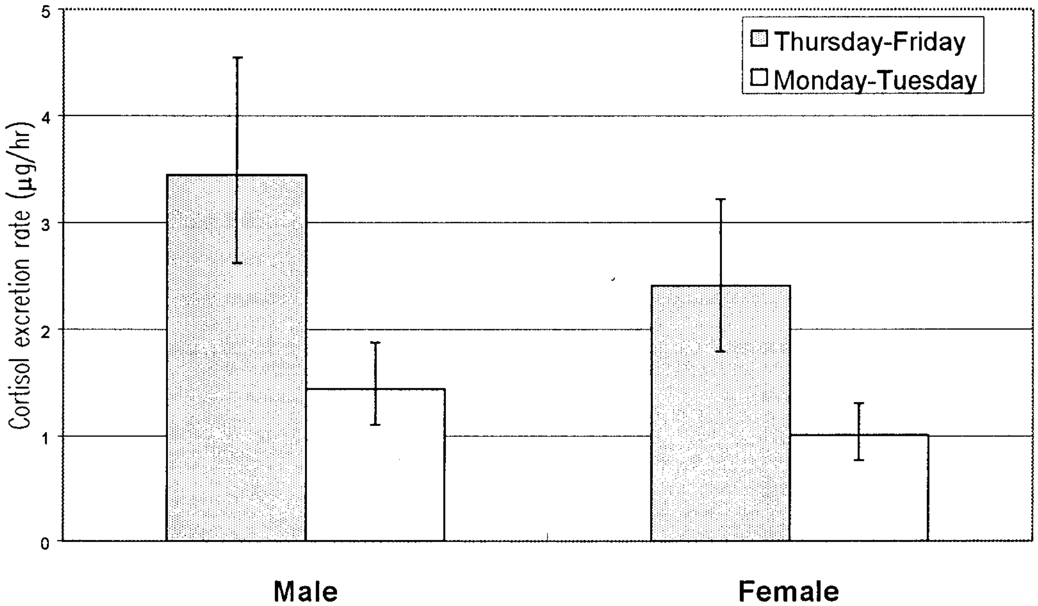

Fig. 2. Regression-corrected mean cortisol (±1 standard error).

TABLE 2. Mean diastolic and systolic blood pressure (± standard error) corrected for significant covariates

	Thursday–Friday	Monday–Tuesday
Diastolic blood pressure (mm Hg)		
Male	84.0 ± 2.54	78.3 ± 2.21
Female	76.2 ± 2.35	70.5 ± 2.37
Systolic blood pressure (mm Hg)		
Male	134.4 ± 3.45	128.6 ± 3.03
Female	121.3 ± 3.24	115.5 ± 3.21

community participated in gambling, and the stakes were trivial. Although the exact details are not known for this particular week, in general the decline in high-stake gambling seems to be a consequence of the one or few winners of substantial sums to withdraw the money from the community. This behavioral phenomenon occurs on a regular weekly cycle in this and probably other Kimberley Aboriginal communities.

Frankenhaeuser's (1989) biopsychosocial model of hormone determinants ascribes mental effort as the primary determinant of epinephrine output and negative affect as the major determinant of cortisol levels. It is clear that gambling could lead to high mental effort, both on the part of gamblers and those watching with strong vested interests, and this may explain the higher levels of epinephrine on the Thursday and Friday. Intense gambling almost certainly involves much emotion, and for most this will be negative and might therefore be expected to lead to increased cortisol output in the group as a whole. Hunter and Spargo (1988) noted that the observer often experiences more intense negative emotion than the player.

There are several possible confounding factors in this cross-sectional study, and the effects described here may not be a direct or even indirect consequence of the behavioral observations noted. The results could be a consequence of unforeseen physical environmental factors, but obvious parameters such as daily temperature fluctuations are small in this tropical environment. In the laboratory, samples were analyzed in a random order and without any knowledge of the field conditions. It is possible that bias self-selection of volunteers led average differences between the two day groups, but what is apparent to the casual observer is that the intense interest in gambling or its outcome is ubiquitous in this community. The validity of the results reported here and their interpretation await more thorough studies

of the activities of community members and longitudinal measures of hormone output.

There are several possible causes of differential urine flow rates in the two day groups, including, for example, differences in physical activity or liquid intake which may themselves be direct or indirect consequences of behavioral differences. In the total Kimberley sample, urine flow rate was generally positively associated with epinephrine and cortisol output, with the exception of cortisol excretion in males (Schmitt et al., 1995). Here we observe the opposite effect, with high flow rates on Monday–Tuesday when epinephrine and cortisol outputs are relatively low. Hence, it is unlikely that the hormone differences between the day groups are mediated through urine flow rates, and this is confirmed by the statistical corrections for flow rate that have been employed and lead to no substantive changes in the patterns.

Studies of people experiencing rapid sociocultural change report high stress hormone levels, and this change is often associated with a poor health profile. These conditions are features of Kimberley Aborigines. Gambling has been implicated as a factor in this web of cultural change phenomena. Hunter and Spargo (1988) have argued that gambling has widespread and deleterious public-health consequences, affecting nutrition, parenting, and the ability to utilize resources over an extended time frame. Furthermore, they report that the effect of losing money is less anxiety-provoking than the subsequent but immediate desire to get more money to continue playing. Therefore, gambling may act as a factor in disease through the physiological consequence of high stress hormone output. Cortisol in particular is known to increase blood pressure (Kenyon and Fraser, 1992), which is associated with cardiovascular disease, and to influence centripetal fat deposition, which is associated with non–insulin dependent diabetes mellitus. In the Kimberley community that was the focus of this study and some other Australian Aboriginal groups, the incidence of these two diseases is several times the Australian average (Gracey and Spargo, 1987; Thomson, 1991).

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